Attorney Docket No.: 021331-000710US

PATENT APPLICATION

SLIP COLLAR

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SLIP COLLAR

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This patent application is a continuation-in-part application of U.S. Patent Application No. 10/368,028, entitled "Slip Collar For Joining Fume Duct Sections" filed on February 19, 2003. This U.S. Patent Application is herein incorporated by reference in its entirety for all purposes.

BACKGROUND OF THE INVENTION

[0002] Ductwork for corrosive vapor exhaust systems is used extensively in many diverse industries, which utilize corrosive or hazardous chemicals to process raw materials or perform manufacturing procedures. Such industries include the semiconductor, plating, wastewater treatment, and pharmaceutical industries. Such ductwork also is required in the many research and development laboratories, which use highly reactive, toxic or otherwise hazardous chemicals. Such chemicals not only can put workers at risk to hazardous fumes, but are also potential sources of contamination and corrosion. Consequently, vapors from hazardous chemicals must be exhausted through leak-proof air ducts to safely remove them from work areas. Duct installations can be very large, consisting of many thousands of feet of ductwork, which may be manifolded and connected to multiple exhaust fans. Forming these duct installations is a time consuming process.

[0003] Typically, ducts are fabricated as sections of standard length(s), which are transported to a job site and assembled there. A leak-proof joint is required between each pair of contiguous sections. Even the smallest installation requires a considerable number of such joints. Joints must not only prevent fumes from escaping in day-to-day operations, but must also remain leak-proof after prolonged exposure to corrosive or otherwise reactive chemicals. In some industries, joints must not fail catastrophically in the event a flame propagates through the interior or, if exposed directly to heat such as from a fire external to the ductwork, fail mechanically or become a source of smoke particulates and other contaminants. In some cases, a sealant must be applied circumferentially to each interface.

[0004] U.S. Patent No. 5,549,949 provides a solution to simplifying what had been the most time-consuming step in joining two sections, *i.e.*, preparing the resin-impregnated surfaces to which a sealant bonds in order to form a leak-proof seal. Unless mating surfaces

near the ends of each duct section were first sanded or otherwise polished, the interposing sealant layer would not uniformly adhere to the surfaces. Pores would form in the hardened sealant and fumes could leak through the pores. These surfaces include the opposed end portions of the inner laminate surface, the opposed end portions of the outer laminate surface, and the exterior surfaces of a "slip" collar interposed internally between each pair of end sections.

[0005] By reducing the time and labor needed to assemble multi-section ductwork, use of the sealant disclosed in the '949 patent can be an important factor in improving the profitability of businesses which sell or install fume ducts. Many installations, however, require joints to have greater integrity to rupture from tensile and flexural loading than can be provided using only mechanical interfacing between the duct sections and slip collar, and sealant bonding. For example, ductwork disposed exterior to a building must be able to withstand flexure due to wind shear. Also, high velocity gases resulting from an explosive chemical reaction within a localized portion of a duct can create a large overpressure, stressing nearby joints even if the duct sections remain intact.

[0006] The method disclosed in the '949 patent for reinforcing a joint is to form a "lay-up" bond by tightly wrapping alternate layers of fabric around the joint seam. The larger the duct diameter, the more layers must be used. Each time a dry layer is wound, it must be "wet out" with a resin component of the sealant. Lay-up reinforcement substantially strengthens the joint to the extent that under tensile loading the duct material is likely to rupture before the joint fails. While not as significant a cost driver as sanding, the lay-up method also entails considerable time and labor. Consequently, there is a need for a faster, easier and thereby more cost-effective method for maintaining duct section joint integrity against internal and external tensile and flexural loading. To streamline ductwork assembly, attachment of a device implementing the method is desirably simple and reliable.

[0007] Embodiments of the invention address these and other problems.

SUMMARY OF THE INVENTION

[0008] Embodiments of the invention are directed to slip collars, methods for making slip collars, duct assemblies, and methods for joining ducts.

[0009] One embodiment of the invention is directed to a slip collar comprising: (a) a tubular outer wall portion; (b) a tubular inner wall portion; (c) an intermediate portion disposed between the tubular outer wall portion and the tubular inner wall portion; (d) a slot

region defined by the tubular outer wall portion and the tubular inner wall portion, wherein at least one of the tubular outer wall portion, the tubular wall inner portion, and the intermediate portion comprises a fiber reinforced plastic material.

[0010] One embodiment of the invention is directed to a slip collar comprising: (a) a tubular outer wall portion; (b) a tubular inner wall portion; (c) an intermediate portion disposed between the tubular outer wall portion and the tubular inner wall portion, (d) a first slot region defined by the tubular outer wall portion and the tubular inner wall portion; and (e) a second slot region defined by the tubular outer wall portion and the tubular inner wall portion, wherein at least one of the tubular outer wall portion, the tubular wall inner portion, and the intermediate portion comprises a fiber reinforced plastic material, and wherein the first and second slot regions face away from each other.

[0011] Another embodiment of the invention is directed to a duct assembly comprising: (a) a slip collar; (b) a first duct including a first end inserted into the first slot region; and (c) a second duct including a second end inserted into the second slot region.

[0012] Another embodiment of the invention is directed to a method for joining ducts comprising: (a) providing a slip collar; (b) depositing a first adhesive composition in the first slot region; (c) depositing a second adhesive composition in the second slot region; (d) inserting a first end of a first duct in the first slot region; and (e) inserting a second end of a second duct in the second slot region.

[0013] Another embodiment of the invention is directed to a method for making a slip collar, the method comprising: (a) forming a tubular inner wall portion; (b) forming an intermediate portion; (c) forming a tubular outer wall portion, and (d) forming a slot region defined by the tubular outer wall portion and the tubular inner wall portion, wherein at least one of the tubular outer wall portion, the tubular inner wall portion, and the intermediate portion comprises a fiber reinforced plastic material.

[0014] Other embodiments of the invention are directed to methods for joining ducts using a slip collar.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 is a perspective view of a slip collar.

[0016] FIG. 1A is a detailed view of region 1A in FIG. 1.

[0017] FIG. 2 is a cross-sectional view of the collar shown in FIG. 1 taken along the lines 2-2.

[0018] FIG. 3A schematically depicts the embodiment shown in FIG. 1 where an outer wall portion and seat are fabricated from a first material, and an inner wall portion and seat base are fabricated from a second material.

[0019] FIG. 3B schematically depicts another embodiment wherein an outer wall portion and a seat are fabricated from a first material, an inner wall portion and a seat base are fabricated from a second material, and a fluoropolymer film is bonded to an inner surface of the inner wall portion.

[0020] FIGS. 4-5 show cross-sections of slip collars according to other embodiments of the invention.

[0021] FIGS. 6A-6G show cross-sections of a slip collar as it is being formed on a mandrel.

[0022] FIG. 7 shows a cross-section of slip collar with one slot region.

DETAILED DESCRIPTION

[0023] In embodiments of the invention, a "slip collar" may include one or two slot regions and may comprise any suitable length. Some embodiments of the slip collar can be used to join two pieces of duct or pipe without slot regions. In other embodiments, a plurality of slip collars may be joined end to end if one slot region is formed at one end of each slip collar. Thus, the slip collars can be used to join tubular articles or can be used to produce tubular networks such as duct networks or pipe networks. The slip collars may be straight, curved, or may have any other suitable configuration.

[0024] One embodiment of the invention is directed to a slip collar comprising a tubular outer wall portion, a tubular inner wall portion, and an intermediate portion. The intermediate portion is disposed between the tubular outer wall portion and the tubular inner wall portion. The tubular outer wall portion, the tubular inner wall portion, and the intermediate portion define a first slot region and a second slot region. The first slot region and the second slot region face outward from each other, and the intermediate portion is between the first slot region and the second slot region.

[0025] At least one of the outer wall portion, the inner wall portion, and the intermediate portion comprises a fiber reinforced plastic material (*e.g.*, a fiber reinforced polymeric material). The fiber reinforced plastic material preferably comprises a chemically resistant material and/or a fire-resistant material. Fiber reinforced plastic slip collars are desirable, since they are more universally adaptable to different chemicals than metal slip

collars. For example, a metal slip collar may corrode when exposed to certain acids, whereas a plastic slip collar may not corrode as easily when exposed to the same acids. Also, ducts made from fiber-reinforced plastic materials are used in the semiconductor and other industries, and the slip collars according to embodiments of the invention are compatible with those fiber-reinforced plastic ducts. Specific examples of fiber materials and plastic materials are provided below.

[0026] Many of the specific embodiments described below refer to the use of a slip collar for joining duct sections. The duct sections preferably include an outer fire-resistant portion and a chemically resistant inner portion. Together, the duct sections and the slip collar may form a duct assembly.

[0027] The slip collars according to embodiments of the invention are especially useful for joining ducts. As explained below, in preferred embodiments of the invention, an adhesive composition can be deposited in the first and second slot regions, and two sections of duct can be joined quickly and accurately, without the need for extensive aligning of the duct sections. Thus, slip collars according to embodiments of the invention can be used to "self-align" two adjacent duct sections. In addition, the joint that is formed between connected duct sections is strong and can have fire resistance and chemical resistance. The slip collars include both inner and outer wall portions. They provide better for joint strength and for a better barrier for fumes than slip collars that are made from only a single layer of material. For example, in order for a gas inside of a duct assembly to leak from the interior to the exterior, a gas would have to traverse through the two wall portions of the slip collar and the walls of the duct sections that are being joined. Also, by using the slip collars according to embodiments of the invention, ductwork can be installed quickly and accurately. A duct network that is formed using the slip collars according to embodiments of the invention will be strong and reliable. Although slip collars for ducts are described in detail, embodiments of the invention may be used to join other types of tubular articles such as two sections of pipe.

[0028] A number of specific embodiments will now be described with reference to the Figures.

[0029] Referring to FIGS. 1, 1A, and 2, in first and second invention embodiments, a slip collar **10**, **100**, respectively, includes a generally cylindrical outer wall portion **12**, **102**, respectively, having an outer surface **12A**, **102A**, respectively, and an inner surface **12B**, **102B**, respectively, to which is centrally attached a generally toroidal seat **14**, **104** formed of the same materials as the outer wall **12**, **102**. While the use of a generally toroidal seat is

described in this embodiment, it is understood that embodiments of the invention are not limited to slip collars with toroidal seats.

[0030] Referring to FIGS. 3A and 3B, the first and second collar embodiments **10**, **100** further include, respectively, a generally cylindrical inner wall portion **16**, **106** having an inner surface **16B**, **106B** respectively, a generally cylindrical "U"-shaped seat base **18**, **108** having a recess **20**, **110** (as also shown in FIG. 1A) respectively, determined by a base portion **18A**, **108A**, respectively, and opposed first and second sidewalls **22A**, **22B** and **112A**, **112B**, respectively (as shown in FIG. 2). Seat base **18**, **108** closely receives and is attached to seat **14**, **104**, respectively. Preferably, the seat base **18**, **108** is formed of the same material as the inner wall portion **16**, **106**, respectively. Alternatively, the inner wall portion and seat base may be formed of different materials.

[0031] Outer and inner wall portions **12**, **16** and **102**, **106** define, respectively, opposed and generally cylindrical first and second slot regions **24A**, **24B** and **114A**, **114B**, respectively (as shown in FIG. 2). The region between the first and second slot regions **24A**, **24B** and **114A**, **114B** may constitute intermediate portions (or a single circular intermediate portion). As indicated in FIG. 1 by phantom lines depicting the end portion **32** of a duct section **30**, each slot region **24A**, **24B** and **114A**, **114B** closely receives an end portion **32** of a duct section **30**. The end portions of the duct sections can be pre-coated with an adhesive sealant composition and/or the slot regions **24A**, **24B**, **114A**, **114B** may include the adhesive sealant composition. Preferably, the adhesive sealant composition includes a settable admixture of curing agent and novolac epoxy resin. Suitable adhesive sealant compositions are described in U.S. Patent No. 5,549,949, which is herein incorporated by reference in its entirety.

[0032] A plurality of set screws **34** may optionally secure the end portion **32** of the duct section **30** to the slip collar **10**, **100**. As shown in FIG. 1, the formed joint is strong and leakproof. The set screws **34** are useful when the adhesive sealant compositions are curing. For example, an adhesive composition that is produced from a material such as ChemBond™ commercially available from ATS Products, Inc. of Richmond, CA may be applied to the walls defining the slot regions with a tongue depressor or squeegee. The end of the ducts that will be inserted into the slot regions may also be coated with the adhesive composition. The duct ends are end inserted into the slot regions and set screws are tightened to hold the assembly in place while the adhesive composition hardens. Excess adhesive composition may be removed. Curing of the adhesive composition can take place by wrapping a drum heater with a temperature regulator set at 180 degrees F around the center of the slip collar.

Heat can be applied for about 5 minutes. Alternatively, a hot air gun can be used to cure the adhesive composition.

[0033] FIG. 3A is a schematic representation of a slip collar **10** with an inner wall portion **16** and a seat base **18** formed of the same material. The inner wall portion **16**, which can serve as a corrosion barrier and/or chemical barrier in some embodiments, may be made from: (a) an admixture of a phenolic resin and catalyst; or (b) an admixture of a vinyl ester resin and catalyst; or (c) an admixture of an isophthalic resin (iso-resin) and catalyst.

[0034] The inner wall portion of the slip collar **10** may have any suitable thickness. The thickness of the inner wall portion **16** when made of phenolic resin can be in a range from about 0.100 to about 0.2000 inch, and preferably is about 0.150-inch. The thickness of the inner wall portion **16** when made of vinyl ester or isophthallic resin can be in a range from about 0.075 to about 0.100 inch, and preferably is about 0.100 inches. The inner wall portion **16** and the seat base **18** can be made different materials.

[0035] Depending on the internal pressure which the duct joint is intended to withstand, the height of base **18**, as determined by the thickness of base portion **18A** and the height of sidewalls **22A, 22B**, is in a range from about 3/16 to about 1 inch. The depth of the recess **20** is about one-half the height of base **18** in this example. The thickness of seat **14** equals the depth of recess **20**. The outer wall portion **12** and the seat **14** can be made from: (a) an admixture of a phenolic resin and catalyst; or (b) an admixture of a vinyl ester resin and catalyst.

[0036] The outer wall portion **12** can have any suitable thickness. For example, the thickness of outer wall portion **12** of the slip collar can be from about 3/16-inch to about 1-1/2 inches.

[0037] FIG. 3B is a schematic representation of a slip collar **100** with the inner wall portion **106** and seat base **108** being formed of the same material. The choices of materials and the ranges of thicknesses for outer wall **102**, inner wall **106**, seat **104**, and seat base **108** can be the same as those for wall **12**, wall **16**, seat **14** and base **108**, respectively.

[0038] Slip collar **100** (as shown in FIG. 3B) differs from slip collar **10** (as shown in FIG. 3A) in that a fluoropolymer film **120** is attached to the inner surface **106B** or inner wall portion **106** of the slip collar **100**. Compared to other plastic materials, fluoropolymers have superior resistance to chemical attack and remain stable at high temperature.

[0039] A fluoropolymer film may be bonded to other parts of the slip collar using any suitable process. For example, U.S. Patent No. 6,441,128 discloses a process for the fluoro-oxidation of ECTFE, which modifies its surface properties so that the film can be adhesively

bonded to plastic and metallic surfaces. Other processes are described in U.S. Patent Application No. 10/255,125, which was filed on November 25, 2002, and is herein incorporated by reference for all purposes. This process can be used to adhere a fluoropolymer film to a plastic laminate. Other processes, which can be used to bond a fluoropolymer film to a polymeric composite, include plasma treatments, corona etching processes, and sodium etching processes. Fluoropolymer films, which are suitable, may comprise polytetrafluoroethylene (PTFE), fluorinated ethylene propylene resin (FEP), perfluoroalkoxy copolymer (PFA), polyvinylidene fluoride (PVDF) and the like. Preferably, the thickness of film **120** is in a range from about 0.001 to about 0.010 inches. More preferably, the film thickness is in the range from about 0.003 to about 0.005 inches.

[0040] The embodiments described above may be made in any suitable manner. For example, the slip collars can be made by molding individual sections of the slip collars and then bonding them together. Alternatively, the slip collars may be formed by molding and then forming the slot regions using a milling process. They could also be made using a mandrel while layering layers of fiber and resin on a mandrel. Some of these methods are described below.

[0041] The embodiments that are described above include a slip collar that includes a U-shaped seat portion that interfaces with a toroidal seat. However, embodiments of the invention are not limited thereto. For example as shown in the embodiments below, the slip collars according to embodiments of the invention may include slip collars without U-shaped seat portions that interface with toroidal seats. FIGS. 4 and 5 illustrate slip collar embodiments that do not include U-shaped seat portions or toroidal seats.

[0042] FIG. 4 shows a slip collar **300** that includes an inner wall portion **300(a)** and an outer wall portion **300(c)**. An intermediate portion **300(b)** is between the inner wall portion **300(a)** and the outer wall portion **300(c)**. The intermediate portion **300(b)**, the inner wall portion **300(a)**, and the outer wall portion **300(b)** may be considered an integral structure in some embodiments. First and second slot regions **300(d)**, **300(e)** are defined by the inner wall portion **300(a)**, the outer wall portion **300(c)**, and the intermediate portion **300(b)**, and face away from each other. As shown in FIG. 1, duct sections (not shown) are received in the first and second slot regions **300(d)**, **300(e)**. As shown in FIG. 4, the inner wall portion **300(a)** is shorter than the outer wall portion **300(c)**. Also, the outer wall portion **300(c)** may comprise two distinct layers or could be in the form of a single distinct layer.

[0043] FIG. 5 shows a slip collar **302** that includes an inner wall portion **302(a)** and an outer wall portion **302(c)**. An intermediate portion **302(b)** is between the inner wall

portion **302(a)** and the outer wall portion **302(c)**. First and second slot regions **302(d)**, **302(e)** are defined by the inner wall portion **302(a)**, the outer wall portion **302(c)**, and the intermediate portion **302(b)**, and face away from each other. Duct sections (not shown) are received in the first and second slot regions **302(d)**, **302(e)**. As shown, the inner wall portion **302(a)** and the outer wall portion **302(c)** are of substantially equal length.

[0044] While both of the embodiments shown in FIGS. 4 and 5 are suitable for joining sections of duct together, the embodiment shown in FIG. 4 has advantages over the embodiment shown in FIG. 5. As noted, the axial length of the inner wall portion **300(a)** is less than the axial length of the outer wall portion **300(c)**. It is easier to deposit an adhesive composition inside of the first and second slot regions **300(d)**, **300(e)** when the axial length of the inner wall portion **300(a)** is shorter than the axial length of the outer wall portion **300(c)**. Consequently, when joining a pair of duct sections using the slip collar **302**, a more reliable joint is formed between them. Joining duct sections is also faster using the slip collar **300** shown in FIG. 4 than the slip collar **302** shown in FIG. 5.

[0045] A method for making the slip collar embodiment shown in FIG. 5 can be described with reference to FIGS. 6A-6H. For clarity of illustration, only the top portion of the mandrel is shown. In some embodiments, the method includes forming a tubular inner wall portion, and then forming an intermediate portion. After the intermediate portion is formed, a tubular outer wall portion is formed. A first slot region is defined by the tubular outer wall portion and the tubular inner wall portion, and a second slot region is defined by the tubular outer wall portion and the tubular inner wall portion. At least the tubular outer wall portion, the tubular wall inner portion, and the intermediate portion comprises a fiber reinforced plastic material.

[0046] FIG. 6A shows an upper portion of a mandrel **200**. The mandrel **200** may be mounted on roller, which can rotate the mandrel **200** so that layers can be formed on it. In some embodiments, the mandrel **200** could be a tapered mandrel, or could be a mandrel with a constant diameter. The mandrel **210** may be made of any suitable material including steel.

[0047] The mandrel **210** may also have any suitable diameter. For instance, the diameter of the mandrel **210** may be, for example, from about 2 to about 84 inches in some embodiments. Although the mandrel **210** is in the form of a cylinder, it is understood that the mandrel could have other shapes in other embodiments.

[0048] FIG. 6B shows a release layer **202** that is placed on the mandrel **200**. The release layer **202** may comprise, for example, a Mylar™ film, and may be used to help separate the formed slip collar from the mandrel **202**. As is known to those of skill in the art,

a layer of cardboard (not shown) may be placed over the release layer **202**. It is possible to place cardboard and/or a plastic film over the mandrel **200** (as in, *e.g.*, U.S. Patent Nos. 5,308,423 and 5,306,371) to facilitate removal of the formed slip collar from the mandrel **200** after it is formed.

[0049] As shown in FIG. 6C, first and second layers **204(a)**, **204(b)** may be wrapped around the mandrel **200** and the release layer **202**. The first and second layers **204(a)**, **204(b)** are preferably made of a compressible material such as cardboard. The first and second layers **204(a)**, **204(b)** can be wrapped around the mandrel **200**, while leaving a space between them. The space will eventually be used to form an inner wall portion of the slip collar. The spacing of the first and second layers **204(a)**, **204(b)** may be adjusted to the particular length of inner wall portion that is desired. If a longer inner wall portion (*e.g.*, as shown in FIG. 5) is desired, then the spacing between the first and second layers **204(a)**, **204(b)** may be increased.

[0050] As shown in FIG. 6D, the space between the first and second layers **204(a)**, **204(b)** is filled with a mixture of resin and a fabric material such as chopped strand mat. For example, a fabric material comprising a three-quarter ounce chopped strand mat impregnated with resin can be wrapped around the mandrel **200**.

[0051] The layer of fabric material may be wet out with more resin, and then can be rolled out with a fiberglass roller to eliminate air pockets and excess resin in the layer of fabric material. At this point, the saturated layer of fabric material may be cured. Curing may take place spontaneously in some embodiments (*e.g.*, if a resorcinol aldehyde resin system is used) or may take place using heat. Heat may be directed to the resin-saturated fabric material using an external heat source to cure the resin. The curing temperature and time may depend on the particular resin being cured. For example, curing may take place at about 150-180 °F for about 20 to about 30 minutes.

[0052] The resin material that saturates the fabric material may include any suitable resin material. A vinyl ester resin is preferably used because of its superior chemical resistance. Suitable vinyl ester resins are commercially available under the tradename Derakane (*e.g.*, Derakane 510A), by Dow Chemical Inc. of Midland, MI. See, for example, "Factory Mutual (FM Products)" by Spunstrand, Inc. at www.spunstrand.com. Exemplary resins include phenolic resins and vinyl-ester resins. In other embodiments, a phenolic resin such as a phenol-aldehyde resin may be used. A suitable phenol-aldehyde resin is commercially available from Borden Chemical, Inc. Other exemplary resins include resorcinol-aldehyde, or phenol-resorcinol-aldehyde based resin systems. Examples of such

resorcinol based systems are in U.S. Patent Nos. 4,053,447, 4,076,873, 4,107,127, and 5,202,189. U.S. Patent No. 5,298,299 discusses layers including phenolic resins. All of these patents are herein incorporated by reference in their entirety for all purposes.

[0053] The fabric material may be glass, random glass mat, woven roving, boat cloth, filament winding, or organic (or inorganic) veils as subsequent layers of glass in order to achieve the desired wall thicknesses. For some applications, the aforesaid fabric materials may be impregnated with graphite or carbon fibers or even ceramic fibers to provide increased strength and fire resistance.

[0054] As shown in FIG. 6E, two spacing elements **208(a)**, **208(b)** are placed on the inner wall portion **206** and the first and second layers **204**. The two spacing elements **208(a)**, **208(b)** preferably comprise a compressible material such as rubber. Compressible spacers are desirable in some cases, since layers can shrink during processing and the spacers can conform to dimensional changes during processing. The spacing elements **208(a)**, **208(b)** are held together by tape. The spacing elements **208(a)**, **208(b)** may be strips of rubber that are wrapped around the mandrel **200**.

[0055] Next, as shown in FIG. 6F, the space between the two spacing elements **208(a)**, **208(b)** is filled with resin and chop stand mat (or other fabric material) and is allowed to cure. Suitable resins and fabric materials are mentioned above.

[0056] Next, as shown in FIG. 6G, a layer **210** of chopped strand mat (or other fabric material) and resin covers the entire top of the spacing elements **208** and the intermediate portion **206**. The layer **210** may be the same or different resin as the resin used to form the inner wall portion **206**. Preferably, the layer **210** is formed using a phenolic resin as phenolic resins have superior fire-resistant properties.

[0057] Then, a filament winding layer **212** is then formed on the chopped strand mat and resin layer **210**. The filament winding layer **212** may comprise the resins mentioned above, and preferably includes a phenolic resin. The filament winding layer **212** may comprise filament winding glass of any suitable yield (*e.g.*, 250 yield). The filament winding glass may be wet out with resin before being applied to the mandrel **200**. The outer wall portion of the slip collar is then formed by the combined layers **210**, **212**.

[0058] Then, the formed composite is cut at points C with a cutting tool such as a saw. The saw may remain stationary while the mandrel **200** rotates the composite. Alternatively, the saw may move while the mandrel and composite remain stationary. Once cut, the cut piece is removed from the mandrel **200**, and the first and second spacer elements **204(a)**, **204(b)** are removed, leaving the first and second slot regions. A pair of pliers can be

used to pull out the spacer elements **204(a)**, **204(b)** to remove them from the slot regions. Then, the ends of the formed slip collar may be trimmed or sanded as desired. In this way, many slip collars may be made at the same time on a single mandrel.

[0059] FIG. 7 shows yet another embodiment of the invention. FIG. 7 shows a slip collar **310** with only one slot region at a first end **320**. The slip collar **310** has an outer wall portion **310(a)**, an intermediate portion **310(b)**, and an inner wall portion **310(c)**. The opposite second end of the slip collar **310** does not include a slot region. As shown, the slot region at the first end **320** of the slip collar **310** receives a duct section **308** (or alternatively another slip collar of the same configuration as slip collar **310**). The duct section **303** (or other tubular structure) may be 20 foot long or more in some embodiments. The slip collar **310** includes a corrosion barrier or liner layer **302** and an outer filament wound structural wall **304**. Both layers **302** and **304** may comprise cured resins and/or fiber-reinforced plastic materials. Although this slip collar **310** has only one slot region, any of the materials, dimensions, and other features described with respect to the slip collars (*e.g.*, with two slot regions) above can be included in this embodiment without departing from the scope of the invention.

[0060] Cone shaped set-screws **306** (or other attachment elements) can be used to hold the duct section **308** in position until any adhesive that is present in the slot region at the first end **320** of the slip collar **310** cures. It is possible to start off with 3 set-screws for the smaller diameter duct sections. The number of set screws may be increased as the diameters increase.

[0061] The embodiment shown in FIG. 7 has a number of additional advantages over a slip collar with two slot regions. For example, the slip collar **310** with one slot region may be joined end-to-end with other slip collars of the same configuration. Thus, the joined slip collars may form a connecting network of ductwork without the need to use slip collars with two opposing slot regions. This makes the installation of ductwork or other types of tubular articles faster and easier. For example, joining two 5 foot long slip collars of the type shown in FIG. 7 to form a 10 foot assembly would require only one joining step. Joining two 4.5 foot long ducts with a 1 foot slip collar with two opposing slot regions to form an assembly would require two joining steps.

[0062] The embodiment shown in FIG. 7 may be formed in the same general manner as described with reference to FIGS. 6A-6G above, except that one of the slot regions would not be formed. For example, to form the embodiment shown in FIG. 7, the same general method could be used, except that one of the spacing elements **208(b)** would not be used.

[0063] The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding equivalents of the features shown and described, or portions thereof, it being recognized that various modifications are possible within the scope of the invention claimed.

[0064] Moreover, any one or more features of any embodiment of the invention may be combined with any one or more other features of any other embodiment of the invention, without departing from the scope of the invention. For example, although the slip collars shown in FIGS. 4-5 do not show a fluoropolymer film, these slip collar embodiments may also include inner walls with fluoropolymer films.

[0065] All patent applications, patents, and publications mentioned above are herein incorporated by reference in their entirety for all purposes. None is admitted to be prior art.